

UNITED STATES OF AMERICA

SPECIFICATION

BE IT KNOWN that I, Christopher Patrick LAWSON of 234 City Way, Rochester, Kent, ME1 2BN, United Kingdom, a citizen of the United Kingdom, have invented new and useful APPARATUS FOR MEASURING THE STRENGTH OF A PERSON'S RESPIRATORY MUSCLES of which the following is a specification.

**APPARATUS FOR MEASURING THE STRENGTH OF**  
**A PERSON'S RESPIRATORY MUSCLES**

This invention relates to apparatus for measuring the strength of a person's respiratory muscles.

Apparatus for measuring the strength of a person's respiratory muscles is known. The known apparatus comprises a mouthpiece and a person is required to inhale against an obstruction in the apparatus in order to see what respiratory pressure the person can generate. This respiratory pressure is known as the maximum inspiratory pressure. The measurement of the maximum inspiratory pressure simply by inhaling against an obstruction does not give an in-depth understanding of the person's respiratory muscles. Such an in-depth understanding of the person's respiratory muscles would be advantageous in many situations. For example, with athletes, an in-depth understanding of an athlete's respiratory muscles could lead to a finding that the athlete's respiratory muscles were weak over a certain respiratory pressure range, and were strong over a different respiratory pressure range. In this case, the athlete could then train his or her lungs especially over the weak respiratory pressure range, in order to strengthen the weak respiratory muscles. Also by way of example, it is mentioned that the majority of those people who die from major surgery actually die from respiratory failure. This is especially so if the major surgery is heart surgery. If an in-depth understanding of the person's respiratory

muscles could be obtained before major surgery, then any weakness in the person's respiratory muscles could be identified. The person could then be given pre-operative exercises in order to strengthen their respiratory muscles over the weak respiratory pressure range or pressure ranges. This would then increase the person's chances of survival after major surgery because it would reduce the likelihood of that person dying from respiratory failure after the major surgery.

It is an aim of the present invention to provide apparatus which enables an in-depth understanding of a person's respiratory muscles to be obtained.

Accordingly, in one non-limiting embodiment of the present invention there is provided apparatus for measuring the strength of a person's respiratory muscles, which apparatus comprises a mouthpiece for the person, a flow transducer, a pressure transducer, a variable orifice valve, a motor for operating the variable orifice valve, and microprocessor control means, the microprocessor control means being such that it is able to control the motor to cause the variable orifice valve to vary its orifice size and thereby to maintain a constant predetermined pressure and enable the measurement of the flow rate generated by the person, or to maintain a constant predetermined flow rate and enable the measurement of the pressure generated by the person.

Usually, the flow rate or the pressure generated by the person will be generated by inhalation, but exhalation may be employed if desired.

Preferably, the apparatus of the invention will be used such that the microprocessor control means maintains different constant predetermined pressures, and measures the flow rate generated by the person at these constant predetermined pressures. If desired however, the apparatus of the present invention may be used such that the microprocessor control means maintains different predetermined flow rates and measures the pressure generated by the person. Either way, a maximum inspiratory pressure curve can be built up, and weak parts of the person's respiratory muscles can be seen from the curve. Corrective respiratory exercises can then be prescribed to strengthen any weak range or ranges of the respiratory muscles. For persons with weak respiratory muscles, the variable orifice will generally be small for the maximum inspired flow rate at a chosen pressure. For persons with strong respiratory muscles, the variable orifice will generally be large for the maximum inspired flow rate at a chosen pressure. Various exercises can be prescribed for persons with weak respiratory muscles over various ranges in order to improve the strength of the respiratory muscles over these ranges.

The apparatus may include a control circuit, the flow transducer being connected to the control circuit, the pressure transducer being connected to the variable orifice valve and to the control circuit, and the control circuit being connected to the microprocessor control means.

The microprocessor control means may comprise a microprocessor circuit, display means, and a keypad.

The display means may be a display screen and/or a hard copy print device.

Preferably, the mouthpiece has a flange at the end of the mouthpiece that goes into the person's mouth. The flange helps the person's mouth to seal around the mouthpiece during the inhalation.

Preferably, the variable orifice valve is a rotary variable orifice valve. With such a rotary variable orifice valve, friction may be independent of applied pressure. The relationship between the resistance to flow and rotation of the valve is able easily to be adjusted by the shape of the orifice.

The rotary variable orifice valve may have an orifice which is of a shape that causes the resistance to flow of the rotary variable orifice valve to increase with rotation. Preferably, the orifice in the rotary variable orifice valve is of a triangular shape. Other shapes may be employed if desired.

The rotary variable orifice valve may comprise a cylindrical member and a sleeve which is a rotational fit with respect to the cylindrical member. The sleeve will normally be a rotational fit over the cylindrical member.

The rotary variable orifice valve may be one in which the cylindrical member has an aperture, the sleeve has the orifice, and the aperture and the orifice are positioned such that they overlap as the sleeve rotates. Alternatively, the rotary variable orifice valve may be one in which the cylindrical member has the orifice, the sleeve has an aperture, and the aperture and the orifice are positioned such that they overlap as the sleeve rotates. Alternatively, the rotary variable orifice valve may be one in which

the orifice is positioned partly in the cylindrical member and partly in the sleeve.

Other types of rotary variable orifice valve may be employed so that, for example, the rotary variable orifice valve may be one in which the cylindrical member rotates and the sleeve remains stationary.

The variable orifice valve may be other than a rotary variable orifice valve. Thus, for example, the variable orifice valve may be a flat plate variable orifice valve. The flat plate variable orifice valve may cause friction which is dependent upon the amount of pressure being placed upon the plate. This friction may need to be overcome by the use of a motor which is larger than the motor required for a rotary variable orifice valve which does not suffer from generated friction. The use of a smaller motor may in turn enable the apparatus of the present invention to be produced in a smaller size. Alternatively or in addition, any battery power employed to drive the motor may be less for a rotary variable orifice valve than for a flat plate orifice valve.

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 shows first apparatus of the present invention;

Figure 2 is a block circuit diagram of the apparatus shown in Figure 1;

Figure 3 shows a curve obtained by measuring pressure against flow and obtaining maximum inspired flow rates for different pressures; and

Figure 4 is a perspective view of a rotary variable orifice valve which is able to be used in the apparatus shown in Figure 1.

Referring to Figures 1 and 2, there is shown apparatus 2 for measuring the strength of a person's respiratory muscles. The apparatus 2 comprises a mouthpiece 4 for being inhaled through on by the person, a variable orifice valve arrangement 6, and microprocessor control means 8. The variable orifice valve arrangement 6 comprises a variable orifice valve 10 and a motor 12 for operating the variable orifice valve 10. The microprocessor control means 8 is such that it is able to control the motor 12 to cause the variable orifice valve 10 to vary its orifice size and thereby to maintain a constant predetermined pressure and enable the measurement of the flow rate generated by the person, or to maintain a constant predetermined flow rate and enable the measurement of the pressure generated by the person.

The variable orifice valve arrangement 6 also comprises a control circuit 20 and a pressure transducer 22. A flow transducer 18 is positioned between the mouthpiece 4 and the variable orifice valve arrangement 6.

The constant respiratory pressure transducer 6 is connected to the microprocessor control means 8 by a lead 14 as shown in Figure 1.

During use of the apparatus 2, for a person with weak lungs, the orifice in the variable orifice valve 10 will usually be relatively small for the maximum inspired flow rate. For a person with strong lungs, the orifice in the variable orifice valve 10 will usually be relatively large for the maximum inspired flow rate. Measurements can be taken of pressure against flow in order to build up a maximum inspiratory pressure curve 16 as shown in Figure 3. If the measurements being taken fluctuate due to uneven

inhalation by the person, then a suitable algorithm may be employed to provide an average for each measurement. The curve 16 is then useful for identifying areas of weakness in the person's respiratory muscles. The person, for example a patient shortly to undergo major heart surgery, or an athlete, can then be given remedial exercises to strengthen their respiratory muscles over the weak range or ranges. In the case of persons about to undergo major surgery, the improved respiratory muscles will increase their chances of survival. In the case of athletes, improved respiratory muscles may result in improved performances.

As shown in Figure 2, the flow transducer 18 is connected to the control circuit 20. The pressure transducer 22 is connected to the variable orifice valve 10 and to the control circuit 20. The control circuit 20 is connected to a microprocessor circuit 24 of the microprocessor control means 8. The microprocessor circuit 24 is also connected to display means 26 and a keypad 28.

As shown in Figure 1, the display means 26 comprises a display screen 30 and a hard copy print device 32. The display screen 30 is shown displaying a maximum inspiratory pressure curve 16. The print device 32 is shown having provided a hard copy print 34.

The mouthpiece 4 has a flange 36 at the end of the mouthpiece that goes into the person's mouth. The flange 36 helps the person's mouth to seal around the mouthpiece 4 during inhalation. The other end 38 of the mouthpiece 4 is cylindrical for being a push fit over a cylindrical part of the constant respiratory pressure transducer 6.



Figure 4 shows a rotary variable orifice valve 42 which is a preferred form of the variable orifice valve 10 shown in Figure 1. The rotary variable orifice valve 42 does not generate friction so that friction is independent of applied pressure. The relationship between resistance to flow and rotation of the valve is easily adjusted by adjusting the shape of an orifice 44. The orifice 44 is of a shape that causes the resistance to flow of the rotary variable orifice valve 42 to increase with rotation. More specifically, the orifice 44 is of a triangular shape as shown.

The rotary variable orifice valve 42 comprises a cylindrical member 46 having a bore 48 and a rectangular aperture 50. The orifice 44 is in a sleeve 52 which is a rotational fit over the cylindrical member 46. As shown in Figure 4, the cylindrical member 46 is in the form of a short tube. During use of the rotary variable orifice valve 42, the sleeve 52 rotates over the cylindrical member 46, and the orifice 44 overlaps by varying amounts the rectangular aperture 50. In this way, the effective size of the orifice 44 is varied. Air flow along the bore 48 and through the orifice 44 is shown by arrows.

The rotation of the sleeve 52 is controlled by the motor 12. The motor 12 is mounted on one side of the sleeve 52. The motor 12 has a pulley 54 which drives an endless drive belt 56. The drive belt 56 is in frictional engagement with the outside of the sleeve 52 as shown. Thus rotation of the pulley 54 clockwise or anticlockwise, causes a corresponding rotation of the sleeve 52 via the drive belt 56. The motor 12 is mounted on a motor mounting plate 58.

It is to be appreciated that the embodiments of the invention described above with reference to the accompanying drawings have been given by way of example only and that modifications may be effected. For example, with reference to Figure 4, the motor 12 may be arranged to drive the sleeve 56 by means other than the drive belt 56. Thus, for example, the drive could be via toothed wheels. Also, if desired, the motor 12 could be mounted in line with the cylindrical member 46 and then connected to the sleeve 52 by an appropriate drive arrangement. Instead of using the rotary variable orifice valve 42, the variable orifice valve 10 may be a flat plate variable orifice valve. Such a flat plate variable orifice valve 10 will generate a certain amount of friction during the measurement of the maximum inspiratory pressure, and this friction may need to be overcome, for example with a larger motor 20, or stronger batteries for driving the motor used in the apparatus of the invention. Alternatively, or in addition, the motor may be mains operated. In Figure 3, the curve 16 has been obtained by causing the microprocessor control means 8 to control the motor 12 to cause the variable orifice valve 10 to vary its orifice size and thereby to maintain constant predetermined pressures, so that the flow rate generated by the person can be measured. If desired however, the curve 16 may be obtained by causing the microprocessor control means 16 to control the motor 12 to cause the variable orifice valve 10 to vary its orifice size and thereby to maintain constant predetermined flow rates, so that the pressure generated by the person can be measured.